

CHAPTER 4. GROUNDWATER

To assist King County in protecting the Vashon-Maury Island groundwater system as a source of drinking water and a resource to important fish and wildlife habitat, this chapter provides an overview of the Vashon-Maury Island groundwater system. This overview provides the following:

- A description of the groundwater flow system, using generalized subsurface profiles to illustrate basic concepts and subsurface features
- A summary of the overall condition of the groundwater resource
- Identification of data sources for additional information
- A description of significant data gaps
- Recommended actions to protect or enhance the groundwater resource.

The information in this chapter was largely derived from the *Vashon-Maury Island Ground Water Management Plan* (Vashon-Maury Island Ground Water Advisory Committee (VMIGWAC), 1998) and from data managed by the King County Ground Water Protection Program. No new explorations or field investigations were completed, except for the island-wide field reconnaissance carried out as part of this effort.

4.1 GROUNDWATER FLOW SYSTEM

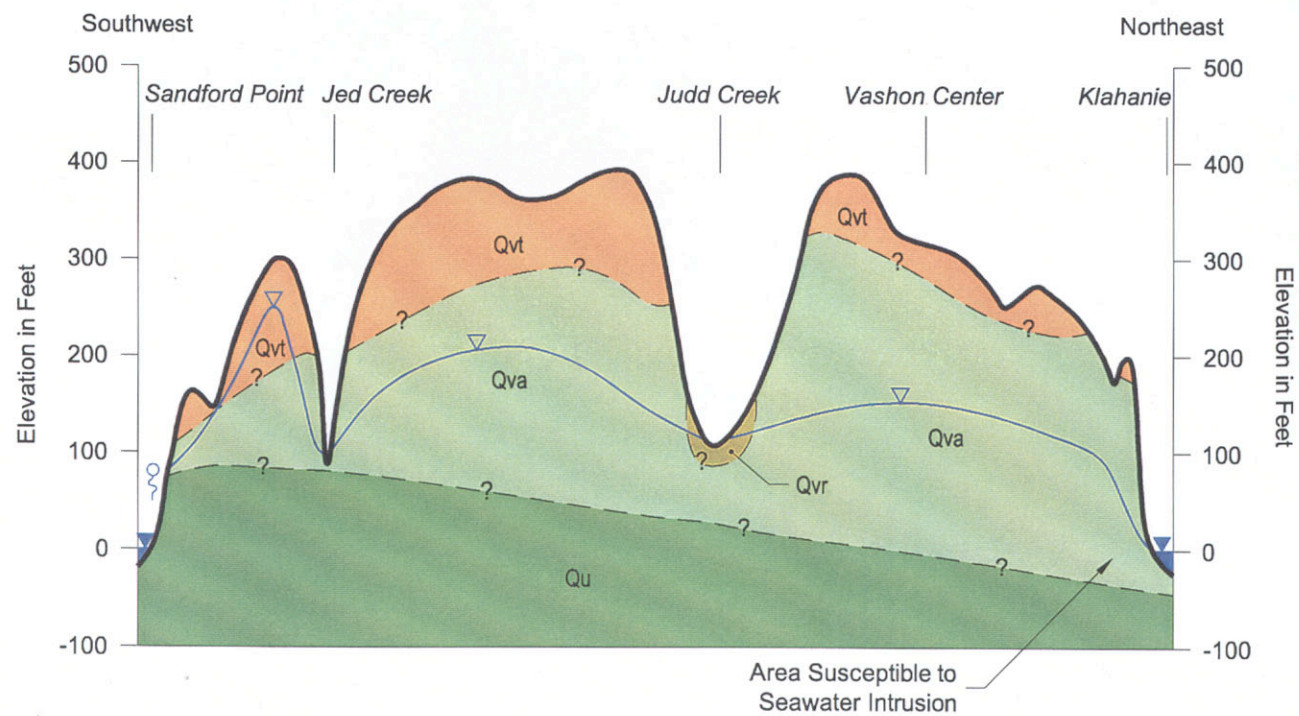
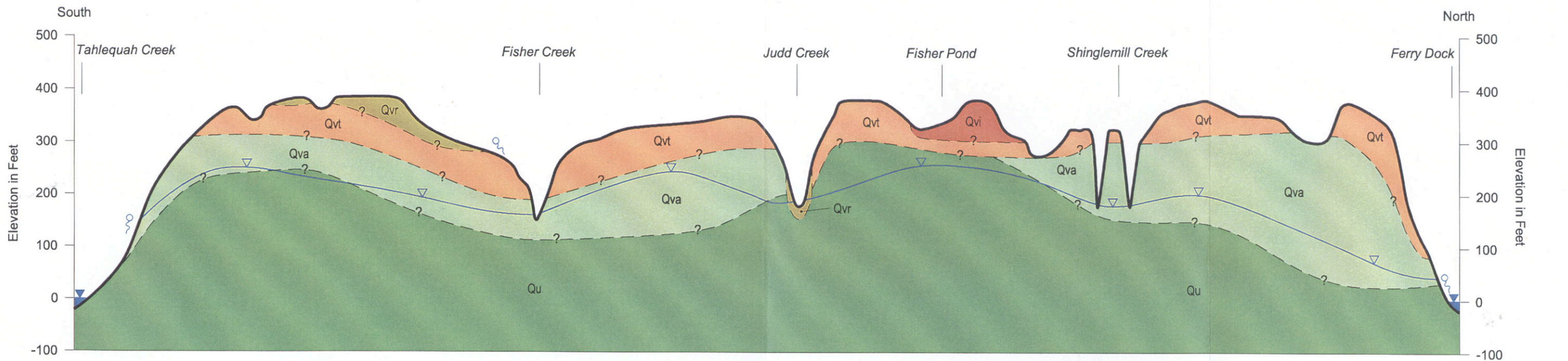
The groundwater flow system beneath Vashon-Maury Island may be best understood by examining the physical mechanisms that influence how water enters, flows within, and exits the system. These recharge-flow-discharge relationships influence the aquifer's susceptibility to pollution; determine its ability to provide year-round base flow to streams, springs, and wetlands; and control the amount of groundwater that is available for sustainable development.

4.1.1 Hydrostratigraphy

Two generalized subsurface profiles are provided on Figure 4-1, illustrating the physical relationship between the primary geologic units considered in this evaluation. These profiles and the following geologic descriptions were largely developed from information provided in Booth (1991), Carr (1983), VMIGWAC (1998), Galster and Laprade (1991), and King County (2001a). The upper profile is drawn through the long axis of Vashon Island from its southern end near Tablequah Creek to its northern end near the Washington State Ferry Terminal. The lower profile is drawn roughly through the middle of the island from Sandford Point in the southwest to Klahanie in the northeast. The locations of these profiles are shown in plan view on Figure 4-2.

The primary geologic units that affect groundwater systems in the project area are described below, from the ground surface downward (from youngest to oldest).

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GEOLOGIC SOIL DESCRIPTIONS

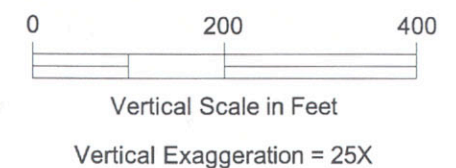
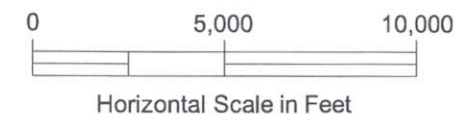
Qvr	Recessional Outwash Deposits
Qvi	Ice Contact Deposits
Qvt	Till
Qva	Advance Outwash Deposits
Qu	Undifferentiated Deposits

LEGEND

	Approximate Groundwater Surface
	Possible Spring Location (For Illustrative Purposes)

NOTE

Hydrogeologic interpretation modified from Booth (1991), VMIGWMC (1998), and King County (2001a).



King County "Rapid Rural Reconnaissance"
Vashon-Maury Island, Washington

GENERALIZED SUBSURFACE PROFILES

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SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4-1

Recessional Outwash (Qvr)

Recessional outwash deposits are predominantly composed of stratified sand and gravel. They were deposited in outwash channels that issued from the terminus of the Vashon glacier as it receded northward from the Puget Lowland approximately 13,500 years ago. Unlike older deposits in the area, the recessional deposits were not over-consolidated by glacial ice; they are typically loose to medium dense.

Booth (1991) mapped four relatively large areas of these recessional outwash deposits. Three are predominantly on upland portions of the island; the fourth is in the valley bottom of Judd Creek.

Precipitation readily infiltrates these deposits, and perched shallow groundwater is commonly found on the uplands where this outwash is underlain by till. Due to their permeable nature and surface exposure, the recessional deposits are considered aquifer recharge areas. Because of these factors and the occurrence of shallow groundwater within them, they are considered highly susceptible to groundwater contamination. They are mapped as such in the *Vashon-Maury Island Ground Water Management Plan* (VMIGWAC, 1998) and the King County web site dnrmetrokc.gov/wlr/wq/groundwater.htm (“i-Map”).

Ice-Contact Deposits (Qvi)

Ice-contact deposits are very similar in texture to recessional outwash. However, they contain collapse features and rare till lenses, suggesting they were not deposited in outwash channels, but rather were deposited adjacent to glacial ice. Like the recessional outwash, they were not glacially overridden and are not over-consolidated.

Booth (1991) mapped one large exposure of these deposits on the upland above the headwaters of Shinglemill Creek. Shallow groundwater in the ice-contact deposits is likely perched on the till that underlies the area. Numerous small lakes and wetlands are found in local depressions where the groundwater intersects the ground surface. Like the recessional outwash deposits, the ice-contact deposits are considered aquifer recharge areas and highly susceptible to groundwater contamination. They are mapped as such in the *Vashon-Maury Island Ground Water Management Plan* (VMIGWAC, 1998) and the King County “i-Map” web site dnrmetrokc.gov/wlr/wq/groundwater.htm.

Vashon Till (Qvt)

Vashon till is the most widespread deposit on Vashon-Maury Island and mantles nearly the entire upland surface. Till is a non-sorted, non-stratified material that was deposited or “smeared” beneath the sole of the glacial ice. It is normally dense to very dense (over-consolidated) and contains a mixture of clay, silt, sand, and gravel. The Vashon till is typically less than 100 feet thick and forms an undulating layer across the island (Booth, 1991).

Till generally exhibits low permeability, and shallow groundwater commonly perches above it where it is overlain by other deposits. Groundwater may accumulate in coarser zones within the till; however, these water-bearing zones are generally not widespread and are not readily recharged. Due to its density, fine-grained clay and silt matrix, and low permeability, till is considered a poor groundwater recharge material, and underlying aquifers generally face little risk from contamination. Maps in the *Vashon-Maury Island Ground Water Management Plan* (VMIGWAC, 1998) and on King County’s “i-Map” web site outline these low risk areas. In general, this widespread till protects large areas of the aquifers underlying Vashon-Maury Island from surface sources of contamination. Where the till is absent, like the stream valleys described below, this protection is not afforded. However, it also limits recharge quantities for water supply.

Advance Outwash (Qva)

Advance outwash deposits underlie the Vashon till and are predominantly well-bedded, medium- and fine-grained sand. They were deposited in outwash channels that issued from the terminus of the glacier as it advanced southward into the Puget Lowland approximately 15,000 years ago. These proglacial deposits were overridden by the advancing ice and are dense to very dense.

As shown on surficial geologic maps (Booth, 1991) and as illustrated on the subsurface profiles (Figure 4-1), the advance outwash deposits commonly crop out along the steep bluffs that surround the island and in the sides of the larger valleys where the streams have eroded through the till mantle. These deposits are generally not found along the upland portion of the island. Although they may be locally absent, the advance outwash deposits typically range from 50 to 300 feet thick.

Groundwater within the advance outwash is the primary aquifer for Vashon-Maury Island. Nearly all the groundwater supply wells found on the island are completed within this unit (VMIGWAC, 1998). Due to its permeable nature, the advance outwash deposits are considered susceptible to contamination where they are exposed at the surface. Some of the largest exposures are found in the Judd Creek valley and near the center of Maury Island. These areas are shown in VMIGWAC (1998) and on King County's "i-Map" web site.

The advance outwash deposits overlie non-glacial or glaciolacustrine silt and clay. These fine-grained sediments form an aquitard below the primary aquifer, and the geometry of this contact significantly influences the occurrence and movement of groundwater within the aquifer. Booth (1991) and VMIGWAC (1998) provide structure contour maps showing the elevation of the base of the advance outwash. The contact is more than 200 feet above sea level in the north-central portion of Vashon Island, but extends approximately 50 feet below sea level in the area roughly between Vashon and Maury Islands. Groundwater frequently discharges to springs and seeps immediately above this contact where it is exposed in the bluffs that surround the island. Where the contact is below sea level, the advance outwash aquifer is in connection with Puget Sound and the threat of seawater intrusion from over-pumping becomes a concern. These relationships are schematically represented on the subsurface profiles shown on Figure 4-1.

Undifferentiated Deposits (Qu)

As described above, fine-grained non-glacial or glaciolacustrine silt and clay deposits underlie the advance outwash. For the purposes of this report, these materials are not differentiated. In part, they include transitional beds, Olympia beds, and the Lawton clay (Booth, 1991). These sediments were generally deposited in a ponded lowland environment before the arrival of the Vashon glacier. A deeper aquifer exists beneath this unit, but due to its depth and isolation from the stream and habitat issues that are of concern to this report, it is not discussed. Information may be found in VMIGWAC (1998).

4.1.2 Groundwater Flow

From a regional perspective, the Vashon-Maury Island groundwater flow system differs from the typical river basin flow systems found over most of King County. Instead of groundwater originating in more mountainous areas and flowing toward a major river drainage, groundwater flow on the island is largely radial and downward, flowing outward from the island's central upland axis toward the lower surrounding Puget Sound salt water body. Several groundwater elevation contour maps that illustrate this pattern are provided in King County (2001a) and VMIGWAC (1998), using groundwater elevation data collected in 1982, 1983, 1989, 1991, and 2001.

Groundwater Recharge

Precipitation falling on Vashon-Maury Island is the sole source of recharge to the island's aquifers. From the land surface, this rainwater either infiltrates downward into the underlying soils or flows overland into isolated lakes or into streams that flow toward Puget Sound. The ability for rainwater to percolate downward and recharge the island's primary aquifer system is directly related to the geologic materials at the surface and to what extent the land surface has been modified or developed

The unconsolidated recessional outwash and ice-contact deposits found primarily along the central upland axis of the island are generally considered the most permeable of the surficial geologic materials. These deposits readily allow rainwater to infiltrate below the ground surface and may be considered significant recharge areas. Where these deposits overlie till, groundwater typically perches on top of the till, forming a shallow groundwater system that forms wetlands and lakes in lower areas. The shallow groundwater discharges into the headwaters of many of the island's surface water streams, providing an important source of base flow to their upper reaches. These shallow groundwater systems are highly susceptible to contamination from sources such as surface spills, septic systems, and misapplication of fertilizers or pesticides. These areas warrant special protection.

The dense and relatively impermeable till that mantles much of the island limits the rate rainfall may recharge the advance outwash aquifer. Infiltration rates for till are typically low and are generally less than rainfall rates, especially during the rainy season. This difference often results in a zone of shallow perched groundwater above the till. The perched water is a source of recharge to the underlying advance outwash aquifer. While the till limits the rate at which rainwater may recharge the aquifer, it also provides an important natural barrier to contamination from pollution sources at the surface. This till mantle provides significant physical protection to the underlying aquifer from contamination from above.

The *Vashon-Maury Island Ground Water Management Plan* (VMIGWAC, 1998) estimates that 55 percent of the island's recharge occurs through the till and the remaining 45 percent occurs in high recharge areas that represent about 25 percent of the land surface area, such as the recessional and advance outwash deposits. The upper reaches of streams and creeks that lie within the upper portion of the advance outwash deposits may be significant groundwater recharge areas if they are at elevations above the local groundwater table. Existing groundwater elevation data is insufficient to accurately define the location of these potential "losing" stream reaches.

Manmade impervious surfaces such as roads and rooftops also restrict rainfall from recharging the aquifer. Where such development occurs, rainfall that naturally would have infiltrated in that area runs off into the surface water drainage system.

Groundwater Discharge

In general, groundwater has the potential to flow from areas of high elevation to areas of low elevation, from areas of recharge to areas of discharge. On Vashon-Maury Island, this flow is largely radial, away from the central upland axis and the recharge areas discussed above, and downward, toward deeper aquifer units and discharge areas such as streams, springs, water wells, and ultimately Puget Sound.

For example, a droplet of rainwater falling near the crest of the island will readily infiltrate into the recessional outwash and ice-contact deposits and perch atop depressions in underlying till, forming a shallow lens of groundwater. These depressions may be lakes, wetland areas, or stream channels. The groundwater that is not lost by transpiration back into the atmosphere through vegetation or discharge as base flow to local streams, is stored within the shallow perched aquifer and slowly infiltrates downward through the till. Below the till, the groundwater particle recharges the island's principal groundwater

aquifer that is found within the relatively permeable advance outwash deposits. Depending on local conditions, this particle will then do one of the following:

- Flow toward and discharge into a stream that has cut through the till mantle and is exposed to the advance outwash, such as Shinglemill Creek
- Flow toward Puget Sound, possibly discharging at one of the many springs along the bluff surrounding the island
- Be captured by a groundwater supply well that provides water for local uses
- Continue to flow downward, recharging deeper water-bearing units.

4.2 GROUNDWATER CONDITIONS

4.2.1 Information Sources

The most comprehensive summary of groundwater conditions on Vashon-Maury Island is the *Vashon-Maury Island Ground Water Management Plan* (VMIGWAC, 1998). The management plan provides a wealth of information related to the island's geographic setting; topography; climate; rainfall; stream flow; land use; groundwater development; water use; water rights; wastewater disposal; water quality; and projected water demands. It also describes federal, state, county, and other agencies with jurisdiction within the management area.

A more recent description of groundwater conditions can be found in the *King County Groundwater Management Program's 2001 Annual Report* (King County, 2001a) and the *2001 King County Benchmark Report* (King County, 2001b). While generally describing groundwater conditions throughout the County, these reports include some new information specific to Vashon-Maury Island. This information includes the results of recent water quality sampling and water level monitoring efforts on the island. Relevant information from these reports and other information sources is summarized below.

4.2.2 Groundwater Quality

The groundwater system beneath Vashon-Maury Island was designated a "sole source aquifer" by the U.S. Environmental Protection Agency (EPA), because precipitation falling on the island is the only source of groundwater and the aquifer is the primary drinking water source for island residents. As such, it is important to protect the aquifer from contamination. Potential contamination sources include: failing on-site septic systems, seawater intrusion, stormwater runoff, leaking underground storage tanks, landfills, industrial properties, land application of pesticides and fertilizers, and wastes derived from animals and livestock.

Available information suggests the island's existing groundwater quality is very good. King County recently conducted a comprehensive set of groundwater sampling efforts on the island as part of its Groundwater Protection Program. The sampling included 21 ambient and eight focused sampling sites whose overall distribution is generally representative of the island-wide groundwater system. Ambient samples were analyzed for coliform bacteria, conventional parameters, metals, nitrates, pesticides, and herbicides; focused samples were analyzed for nitrate and chloride. A map showing sample locations, and tables summarizing sample results are provided in King County (2001a). Elevated nitrate levels were detected in five wells, and elevated chloride levels were detected in three wells. The County is planning to conduct additional sampling in these areas to identify the source and extent of these contaminants.

Available information also suggests that nitrate and chloride contamination may be considered the most significant threat at this time. Elevated nitrate levels may result from failing septic systems, over-

fertilization, livestock waste or land clearing activities. Elevated chloride levels may result from seawater intrusion into the fresh water aquifer.

4.2.3 Groundwater Supply

Using citizen volunteers, the King County Groundwater Management Program collected groundwater level measurements from 23 wells in 2001. Previous island-wide surveys of groundwater levels were conducted in 1982-83 (Carr 1983) and in 1989-91, as part of the *Vashon-Maury Island Groundwater Management Plan*.

The data from these surveys did not show any trends that would suggest groundwater levels are declining or that the aquifer is being over-drafted (King County, 2001a). However, due to naturally occurring seasonal groundwater level fluctuations and climatic variations, the frequency or length of record of groundwater level measurements may not be sufficient to identify statistically significant changes or trends. Additional water level measurements, collected throughout the year, may be necessary to demonstrate with confidence whether the primary advance outwash aquifer, and deeper aquifers, are being effectively recharged and are safely capable of providing additional supplies, or whether they are being overdeveloped and threatened.

4.2.4 Management Programs and Regulatory Agencies

There are many management programs and regulatory agencies whose jurisdiction and responsibilities include some aspect of protecting the quality and quantity of groundwater on Vashon-Maury Island. These programs and agencies have implemented or are implementing the functions that are necessary to protect the resource. These include the following:

- The King County Ground Water Protection Program, whose primary function within the Department of Natural Resources and Parks is to implement the King County Council's Groundwater Protection Program ordinance, conduct groundwater sampling and analysis, measure groundwater levels, manage related databases, and coordinate efforts with other agencies.
- The Vashon-Maury Island Ground Water Protection Committee, whose primary functions are to participate in the implementation of the Groundwater Management Plan, advises elected officials, coordinate community needs with local organizations, and make policy recommendations.
- The Washington State Department of Ecology, whose primary function is to protect the waters of the state, also issues discharge permits, performs compliance monitoring at the Vashon Island Sewage Treatment Plant, oversees the cleanup of hazardous material leaks and spills, regulates underground storage tanks, implements the groundwater quality standards, issues water rights, regulates well construction and abandonment, and develops stormwater management practices.
- The Seattle/King County Department of Public Health, whose primary functions are to manage smaller (Group B) public water supply systems, septic systems, sewage treatment and disposal facilities, and solid waste landfills.
- The Washington State Department of Health, which has the responsibility for wellhead protection programs and larger (Group A) water supply systems.
- The EPA, whose functions include regulating and monitoring the sole-source aquifer program, sewage waste disposal, sludge application, spill control and prevention, solid waste handling, and stormwater runoff.

4.3 STORMWATER MANAGEMENT

The Washington State Department of Ecology updated its *Stormwater Management Manual for Western Washington* in 2000, and the 1998 *King County Surface Water Design Manual* will be updated to be in compliance with Ecology's update. One of the primary objectives of these manuals is to provide technical standards and guidance on controlling the quantity and quality of stormwater produced by new land development and redevelopment. Largely due to the status of threatened and endangered salmon and the degradation of stream habitat, an increasing emphasis is being placed on the infiltration of stormwater as a management practice to minimize or mitigate the impact of stormwater runoff. Infiltration also provides aquifer recharge benefits and helps maintain stream base flow. Stormwater management practices on Vashon-Maury Island should seek to achieve the following goals when being implemented:

- Mimic as closely as possible the natural hydrologic function of the watershed
- Maximize the protection of surface and ground water quality
- Optimize base stream flows
- Maximize ground water recharge
- Preserve natural stream morphology
- Preserve aquatic habitats

King County staff is currently recommending infiltration as the preferred method of stormwater control on Vashon-Maury Island. The 1998 *King County Surface Water Design Manual* should be amended to reflect this recommendation because both islands are sole source aquifers.

4.4 CONCLUSIONS AND RECOMMENDATIONS

Based on the review of readily available information, a one-day reconnaissance tour of the island, and several conversations with County staff, it is recommended that any rural drainage or capital improvement project on the island be designed to do the following:

- Protect significant groundwater recharge areas.
- Encourage low-impact development and promote stormwater infiltration.
- Control potential pollution sources.
- Maintain groundwater base flow to streams, lakes, wetlands, and springs.
- Avoid over-use of the advance outwash aquifer (the island's primary source of drinking water).

With these principles in mind, we developed the following specific recommendations.

- Protect and preserve upland lakes and wetlands that occur in recessional and ice-contact deposits in their natural state. In addition to providing ecosystem and wildlife benefits, these locations are susceptible to shallow groundwater contamination from surface pollution sources, provide recharge to the advance outwash aquifer, and likely contribute significant volumes of groundwater base flow to neighboring creeks. Possible locations that were visited during the field reconnaissance include Johnson Pond, Fisher Pond, and the Smythe and Meadowlake properties.
- Increase the frequency of groundwater level monitoring across the island. Due to naturally occurring seasonal groundwater level fluctuations and climatic variations such as drought, the currently available groundwater level measurements are not

sufficient to identify statistically significant changes or trends that could indicate whether the aquifer is being over-developed. Static water level measurements should be collected a minimum of four times per year or once per season. In addition, these data will help define gaining and losing stream reaches and will assist with future water balance calculations.

- Continue to monitor groundwater quality for indications of seawater intrusion, primarily near areas where the advance outwash aquifer extends below sea level.
- Assess the relative risks and benefits associated with stormwater infiltration to the Vashon-Maury Island aquifer versus stormwater runoff into surface water streams and lakes, and consider developing infiltration best management practices that are island specific. Island-specific guidance may facilitate the implementation of safe stormwater infiltration.
- King County staff is currently recommending infiltration for controlling surface water runoff on Vashon-Maury Island. The 1998 *King County Surface Water Design Manual* should be amended to reflect this recommendation because both islands are sole source aquifers.